AMYGDALA $z \mapsto z^2+c$

A Newsletter of fractals & $\mathcal{M}$ (the Mandelbrot set)
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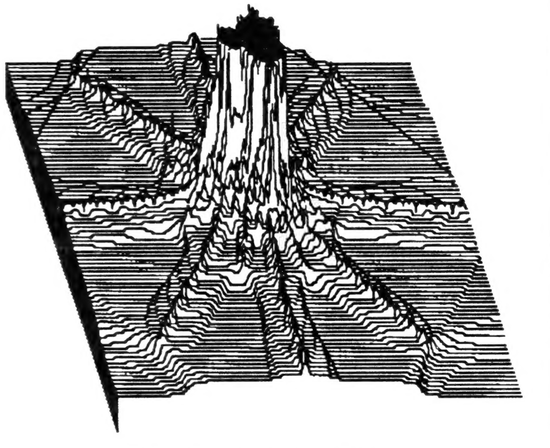
THE DEVIL'S TOWER

—*Ken Philip*

I thought you might be interested in a new view of the John Dewey Jones midget (masquerading as the Devil's Tower!). The picture was done by combining a wire-frame 3D representation (with hidden-line removal, of course...) using dwell as the z-axis with scale exaggerated by a factor of 2, with a 'normal' plot of the Set displaced vertically to line up with the top of the 'mesa'.

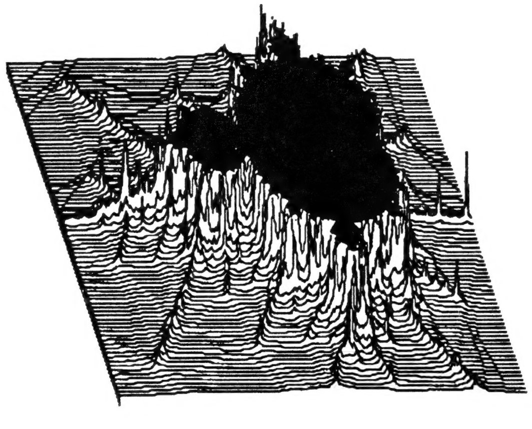


John Dewey Jones Midget
70,000 diameters, dwell limit 80.

Several other views appear as well; all have escape radius 2.

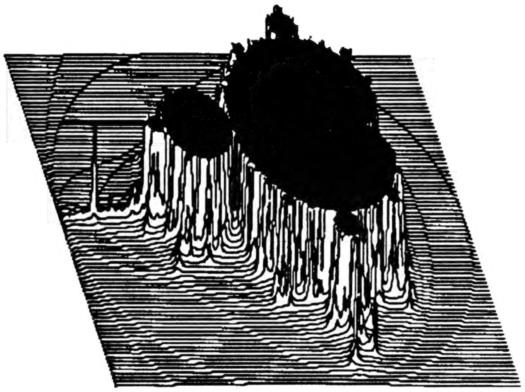
The current version of the 3D Mandelbrot program uses a grey pen pattern to delineate the vertical 'wall' on the left edge. This keeps the 'wall' from blending in to the black pattern in the set itself (top of the 'mesa'). At 48% reduction the grey is too dark (I have a version now that yields a lighter grey), but at 96% the grey is fine.

The reason for the 'unsupported' spikes on some plots is that the contour plotting routine plots every third real-axis pass only, while the routine that fills in the Set with black plots every line.



Biggest Midget
50 diameters, dwell limit 75

RS: When I asked Ken how he did the hidden line removal, he said that he plotted the picture elements from the rear to the front, so newly plotted elements overplot earlier ones, obscuring them. Simple!

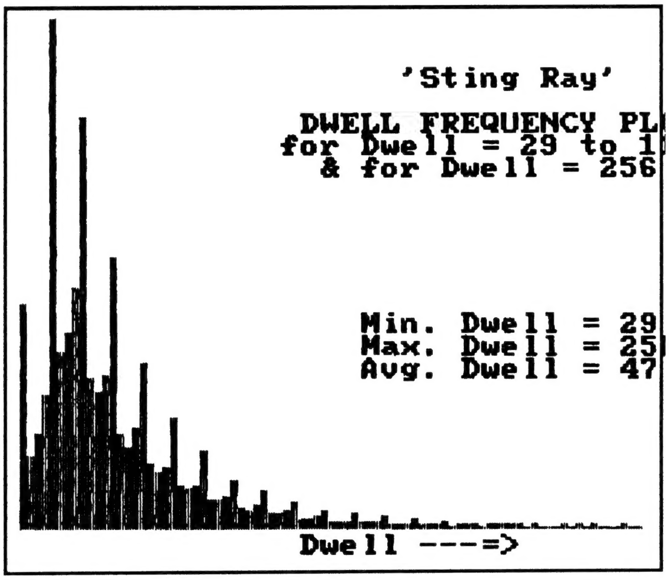


The Mandelbrot Set
1 diameter, dwell limit 75

THE SLIDES

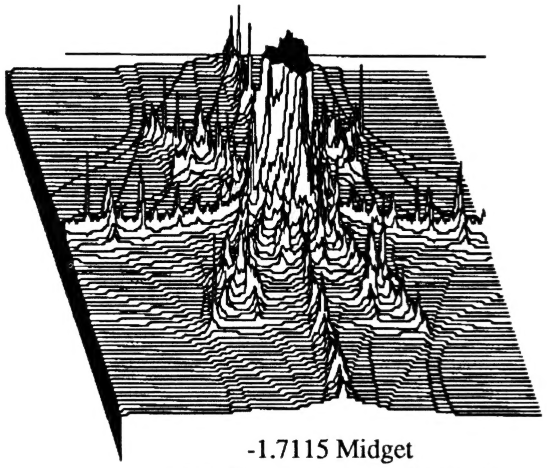
Those subscribing to the color slide supplement now have the third set of four slides of the current series of 24 slides.

144. Andrew LaMance, "Sting Ray": -1.94254 x 13,221. Dwell Limit = 256, Escape radius = 2, pixels = 320H x 200v. Looking at a dwell frequency histogram for this picture (see below), we see that every fourth dwell (29, 33, 37, 41, etc.) is a spike, meaning it occurs quite often. Why is that? Interesting ...



214. John Dewey Jones: “Buddha’s Heart”. Another 250-fold decomposition of the Big Picture (see DECOMPOSITION article), using various colors.

519. Ken Philip: A midget at 2x10^{12} diameters, much farther out the spike than the John Dewey Jones midget; ER = 100.



-1.7115 Midget
1000 diameters, dwell limit 85

911. James E. Loyless: Quetzalcoatl, Aztec God of Sun and Moon: This Julia set is the eye of a dragon, taken from a point on one of the “midgets” from the proboscis of the main M set. Its symmetry and angular quality suggest an Aztec icon, and its form suggests the sun and moon. It seems to point out the compass points, first as eight and then as 32 points. Even the ripples surrounding the form are split symmetrically. Study this image and you will invoke its sense of order.

DECOMPOSITION: THEY WENT THATAWAY — ANOTHER WAY OF VIEWING THE OBJECT

—John Dewey Jones

We usually generate the Object by applying a simple iterative process to points in the complex plane, then assigning colors to the points based on the number of iterations that will take the starting point out to the escape radius. Of the many other ways to render the Object, one of the most interesting shows us where the point was when it passed the radius.

Just as in the orthodox method, we select some initial value z_0 and repeat the calculation

$$z_n \leftarrow z_{n-1}^2 + z_0$$

until for some *n* we have

$$|z_n| \le R \quad \text{and} \quad |z_{n+1}| > R$$

where R is our chosen escape radius. Now recall that any complex number *z* can be written in the form $re^{i\theta}$, where

$$\theta = \tan^{-1}(\mathrm{Im}(z)/\mathrm{Re}(z))$$

Since we’ve just passed the escape radius, we know that the *r* part of this is pretty close to R, so it remains only to figure out the θ part and assign colors appropriately. We can calculate the θ corresponding to the final value of z_n from:

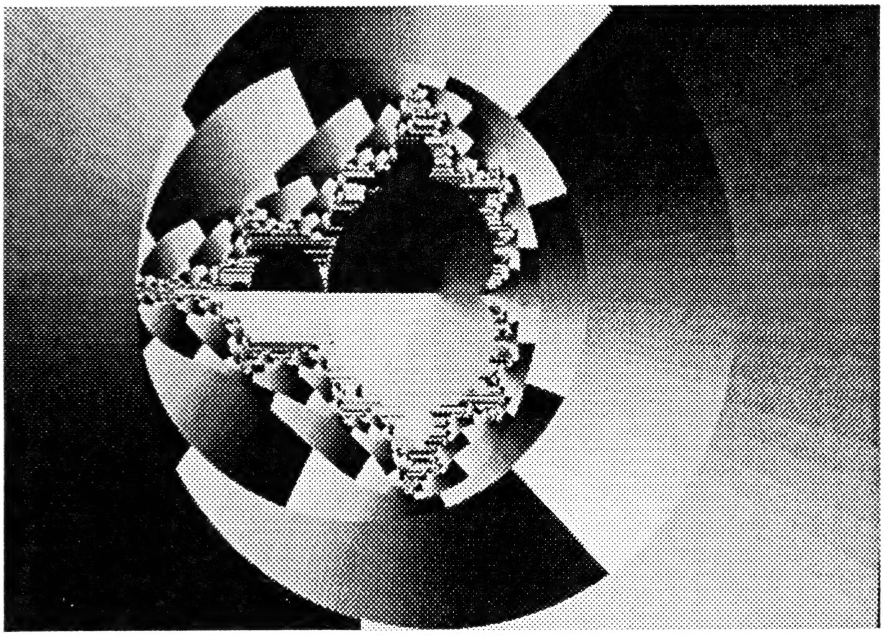
$$\theta = \tan^{-1}(\mathrm{Im}(z_n)/\mathrm{Re}(z_n))$$

Then, supposing that we have L colors at our disposal, we determine which of L distinct sectors between 0 and 2π this angle falls into. We assign the angle to sector *l* if

$$2\pi(l-1)/L \leq \theta < 2\pi l/L \qquad (1 \leq l \leq L)$$

We can now color the points based on the value of *l*, in the same way as we conventionally assign colors based on the value of *n*. Although we're not explicitly assigning colors to the different dwell zones as such, the dwell zones are clearly distinguishable in the resultant image.

It is possible to use both integers, *n* and *l*, in assigning a color to the current pixel. What combination you choose depends on the colors you have available and your personal taste. The following picture is a greyscale rendering of a 250-fold decomposition of the Big Picture, I was able to select from a palette of 256 shades, using (l + 7n) mod 256 to combine the two integers. I took L to be 32. This choice gives images which are attractive but not particularly illuminating.



This technique is described in fractal literature under the name of 'decomposition', most commonly setting L = 2, when it's called 'binary decomposition'. Peitgen and Richter discuss this in TBF, pages 40-44, and present several black-and-white images. I found their discussion somewhat impenetrable — any exposition which includes phrases such as "we invoke the well-known Bashi-Bazooka Theorem for non-orthogonal spinach bases in Banach spaces..." makes me feel that the authors didn't have readers like me in mind when they wrote it — but I got the impression that there are many interesting ramifications to this method, which I may come to understand in time. If any reader can explain this material without assuming knowledge of the Bashi-Bazooka theorem, I hope they will write.

DIMENSIONS — Part 1

—Daniel Beisenherz

Why is a fractal called a fractal? What does it mean if somebody says its dimension cannot be measured by an integer? Something seems to have gotten mixed up, thus it's high time to shed light upon this confusion.

Euclidean Dimension

It is probably well known to all of us that when we tell someone, "Yesterday I saw a 3-D movie", we don't assume he has difficulty understanding us. He knows that we were impressed by the way the images came out of the normally two-dimensional screen.

When about 300 B.C. Euclid started mulling over the different geometric elements, he came to the conclusion that not everything is of the same complexity. He knew that a tetrahedron is more complex than a plane, which is more complex than a line, and so forth. Euclid made the following distinctions:

i) A point is what has no length.
ii) A line is what has no thickness.
iii) The ends of a line segment are points.
iv) A plane figure has only length and breadth.
v) The boundaries of a plane figure are lines.
vi) A body has length, breadth and height.
vii) The faces of a body are planes.

Sounds pretty philosophical! In our modern world, where we try to count all and everything, we could attempt to reword it a little without losing its meaning: "A set is called n-dimensional when we need at least n coordinates to describe all of its points."

Time to look at some examples:

A single point is zero-dimensional, because we don't need to describe its location, no one ever could confuse it.

A straight line is surely one-dimensional, even if it is moved somewhere in space. One coordinate is sufficient to refer to every one of its points (think of the distance to the origin, where points at the left side of zero may have negative value, while those right of zero are positive).

A plane and a disk are two dimensional, while a body like a sphere or a cube is three-dimensional.

If you are familiar with vectors, the dimension of an object could be described as the minimum number of linearly independent (which means: not having the same direction) vectors you need to reach the points. These vectors are called "base vectors". To achieve your goal you may stretch them (multiply by a real number) and add them to each other as you like.

Let's discuss the dimension of the boundary of a two-dimensional object. In the case of a disk this would be a circle. No one doubts (I hope!) that the disk is two-dimensional: we need exactly two vectors to get to every point. We all know how to measure its area, which is greater than zero (a radius of zero yields a single point!).

But what about its perimeter, the circle? Is it one- or two-dimensional? There are two ways to argue: The circle has a certain finite length, but no thickness: its area would equal zero. Thus, we can consider it to belong to the same class of objects that the line does, whose dimension we know is one; therefore the dimension of the circle is one!

On the other hand, if one base vector would be sufficient, by which vector operation (scalar multiplication or vector sum) could we describe a point on the circle that is not the vector's head or tail, but is at an angle to it? We need at least two vectors, therefore the dimension equals two! Oops; how can this contradiction be resolved?

An answer exists, which can satisfy both arguments: The circle, as we usually imagine it, in a normal, right-angled coordinate system, as a subset of the Euclidean plane, has to be called two-dimensional. It has a length (its diameter) and a breadth (also its diameter), if we think of it as a whole unit, although it's empty in the middle.

But it is somehow similar to a line, since there is a continuous mapping from it to the unit interval. (Take a point on the circle and map it to the number that results when you divide the length of the arc from some fixed starting point to the point in question by 2π). This image would be one-dimensional, but unfortunately the circle appears as it is, and not as mapped somewhere else. But to encourage those who feel sympathy for the first point of view: there are spaces and coordinate systems in which the circle appears to be one-dimensional. You can hardly call it Euclidean dimension because the dimension can be seen as the number of perpendicular coordinate axes (namely one).

Euclidean dimension (usually denoted by E) is always an integer ≥ 0. If somebody tells you that the Euclidean dimension of von Koch's snowflake is fractional, meaning that you need at least 1.5 (or whatever fraction) coordinate axes to describe it, this person must either be joking, or he doesn't understand the fundamentals of math!

Topological Dimension

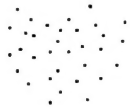
This concept is more sophisticated. We don't consider an object to be of large dimension merely because the Euclidean space which contains it has many dimensions. That would be too materialistic. We're now looking for a measurement that tells us something about the quality of the set we examine. Therefore we consider how difficult it is to break apart our object of interest. We denote the **topological dimension** of our object by **Dt**, and define it as follows:

i) A set of unconnected points is zero-dimensional.

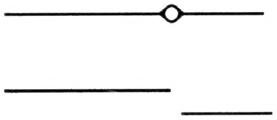
ii) A set has dimension Dt if it can be disconnected by a set of dimension Dt-1.

Here you see that Dt is defined recursively, meaning that Dt is defined in terms of Dt-1, which (if greater than zero) is defined in terms of Dt-2, etc. The way to understand this definition is to look at some examples.

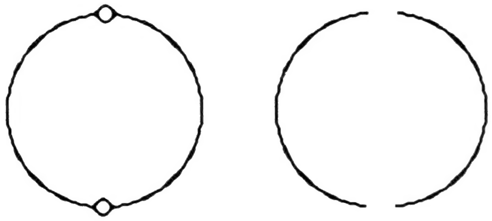
Any **finite** set of points is unconnected, hence topologically zero-dimensional:



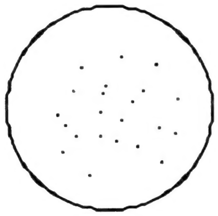
A curve (or straight line) is topologically one-dimensional, because it can be disconnected by taking out a finite number of points, itself forming a one-dimensional set. For instance we can disconnect a line segment by removing a single point from it, dividing it into two separated pieces:



A circle has Dt = 1 also: If we take out two opposite points, we can then pull the two half-circles apart:

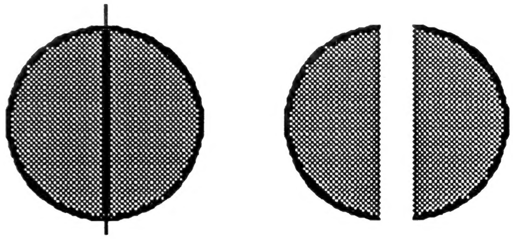


A disk, however, is two-dimensional. If we remove a finite number of points, we only make some tiny holes in it, and cannot pull it apart:

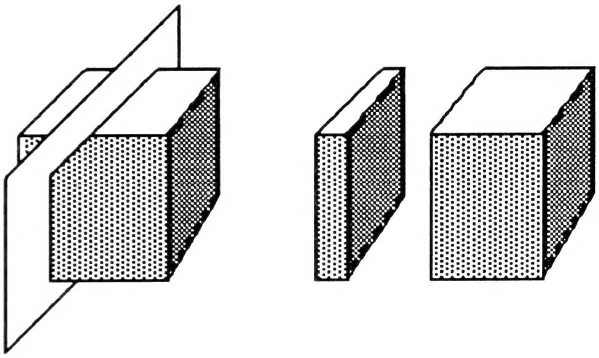


We can, however, divide it into two parts by removing a line — its vertical diameter, say. Since the line has dimension 1, the disk has dimension one greater (See diagram at top of next page).

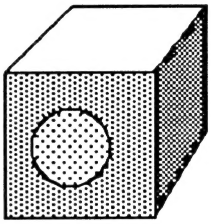
What is the topological dimension of a cube? The cube cannot be disconnected by deleting a finite number of points or lines, but by removing a plane section (or something more irregular, but with Dt = 2) it can be disconnected. Therefore



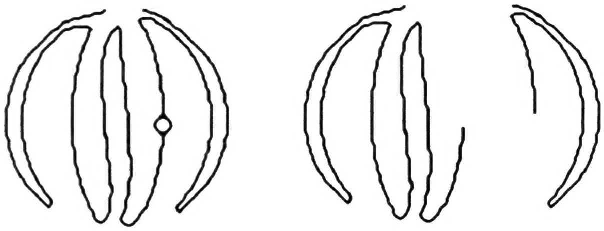
it has $Dt = 2+1 = 3$. Remember that we are talking about sets of points here; a geometric object can be seen as a point set. Generally these sets contain an infinite number of points.



What about the *surface* of a cube: the set of all six faces? Its topological dimension is only 2, as opposed to its Euclidean dimension of 3: A circle removed from any face disconnects the figure — the disk inside the circle can be removed from the face:→



Please note that objects do exist for which Dt exceeds E by 2. A simple example, where $E = 3$ but $Dt = 1$, would be a ball of special wool having only length, no thickness:



If it's kinked enough — conforming roughly to the surface of a sphere, say — we must admit that $E = 3$, whether we like it or not. But you can see that it's sufficient to remove a few points (1 in the figure), cutting it at a finite number of locations, to be able to disconnect it. Therefore $Dt = 1$ only. Sierpinski's tetrahedron [1] also has $E = 3$ and $Dt = 1$, because it consists of only one (awfully kinked) curve which has no thickness (to mention Euclid again).

There is a mathematical method which links both of these concepts of dimension. Consider a projection from a Euclidean space containing an object to one of lesser dimension. The surface of a sphere can be opened by a finite number of cuts (like paring an apple) and then projected onto a plane by bending and distorting it (throw the paring on the floor and step on it, if it isn't already plane). Our ball of wool could be unraveled into a straight line, which can easily be projected onto a one dimensional Euclidean space — a coordinate axis. Note that bending the object and subtracting a finite number of subsets of dimension Dt-2 (here: cuts) does not change the topological dimension (For a proof, refer to [2]).

Since Dt always appears to be an integer also, we still don't know why people use the term *fractal*. What we now know is that there are different points of view as to the dimension of certain geometric objects. But how can something be said to have a dimension of 1.261859...? What we've seen in our examples also, is that Dt is always less than or equal to E. This surely can't be proved by examining a finite number of examples, but I hope this has convinced you. Since evidently $Dt \geq 0$, we have so far:

$$0 \leq Dt \leq E \qquad (1)$$

References

[1] Rainer Urian, **"Wir bauen uns ein Monster",** c't (May 1988) 146-158. (Turbo Pascal listing included).

[2] M.G. Barrat and M.E. Mahowald (eds.), **"Geometric Applications of Homotopy Theory I",** Springer-Verlag, NY (1988).

DIMENSIONS — part 2 will appear in Amygdala #14.

FRACTAL SOFTWARE CONTACTS

1. HEATH-ZENITH

— Bob Doolittle

I would like to volunteer to be your contact for the Heath/Zenith Z100 computer. In case you're not familiar with this machine, it is not an IBM PC compatible. It has dual CPUs (8088 and 8085). I am currently running MSDOS 3.1 on it. It has 768K of user RAM and an additional 192K of dedicated bit-mapped video RAM (64K per color plane). My CPU speed is 8 MHz and I am also using an 8087 math coprocessor. The standard screen resolution is 640 x 225 in full color.

I have been playing with Mandelbrots since the Dewdney column in S.A. I have also been interested in fractals of all kinds for years. My Mandelbrot generator is written entirely in 8088/8087 assembly language. It writes the iteration data file for a 200 x 200 picture. A separate program reads the data file, assigns colors and does the screen plotting. Since the aspect ratio is approximately 2:1, I duplicate the horizontal pixel data to get a nearly square picture. This also easily permits dithering colors on the horizontal scan lines to achieve more than the standard 8 RGB colors. I normally use a dwell limit of 200 which, without any "tricks", takes anywhere from a few minutes to a half hour to generate a data file. Each data file is 40K without any compression.

I would be happy to share my source code as well as the data files with others who may be interested. I would also include other fractal programs I've developed over the years. These programs work only on the Z100 but the disk format is the same as IBM. Six dollars per disk seems like a fair price.

My background is in high energy astrophysics and I've worked as a scientific spacecraft experimenter in this field for 25 years. Five years ago I took early retirement to change careers and become a system analyst and programmer part time at Ashton-Tate. I've also had my own business of writing and selling software since 1980. The programs are mostly system utilities for CP/M and DOS.

This reminds me that I've heard the M-set described as everything from the Big Bang to an ass, but I haven't heard it likened to a Black Hole. Maybe some of your more imaginative subscribers can try this as the "object".

Robert F. Doolittle
RD Software
1290 Monument St
Pacific Palisades, CA 90272
(213) 454-8270 (Fri, Sat, Sun + Eves)

2. COMMODORE C-128 AND C-64

—*Joe Lindsay, III*

Northeast Missouri State University
465 Dobson Hall
Kirksville, MO 63501 (Starting 9/5)

FRACTAL CALENDARS

1. Loyless' 1989 Fractal Calendar

Dear Fellow Fractal Fancier:

My 1989 Fractal Calendar is now available for interested fractaliers. It is in an 8-1/2 x 14 inch format (same as the 1988 calendar) and contains thirteen high-resolution black and white (printer) images.

Most of the images use a 1400 x 1200 dot array for exceptional clarity. There is also a monthly commentary based on the theme "The Planets" (plus a few other orbs).

Price is $5.00 each ($6.00 by mail, postpaid). Submit orders with name, address, and zip code to:

FractalCal 89 • c/o J.E. Loyless
5185 Ashford Court
Lilburn, GA 30247

2. Fractal Cosmos 1989

The Amber Lotus 1989 Fractal Cosmos calendar boasts thirteen high quality color reproductions of images similar (or identical) to ones found in *The Beauty of Fractals* and *The Science of Fractal Images,* except that they are larger (8" x 10"). "Through artistic choice of color and composition, simple mathematical formulas are transformed into computer generated works of art. The pictures in this calendar are genuine results of mathematical experimentation. They demonstrate the unexpected variation of structures that develop based on the simplest laws. As we look at the images, we have the opportunity to consider scenarios with an interplay between order and chaos, and to contemplate the boundaries we normally associate with art and science."

Available from **Amygdala** for $9.95, postpaid ($11.95 overseas). Ideal for Christmas presents!

SUBSCRIBERS' SUBSCRIPTIONS

I would like to put a notice about Amygdala in as many computer-related publications as feasible, and can use your help, subscribers! Please send me names and addresses of computer-related publications that you read.

MANDELZOT 0.94

—*Dave Platt*

I'm enclosing a disk with a copy of the latest working version (0.94) of my MandelZot program for the Macintosh II. This version is a bit more recent than the one (0.9) that Ken Philip recently reviewed...

In version 0.92, I rewrote the color-selecting subroutine to construct a "contrast" palette, per his suggestions, and also added a feature that can be used to request "square" pixels.

Version 0.94 incorporates a "flash update" feature that greatly increases the speed of screen refresh in 8-bit-color mode, supports dwells of up to 32765, permits dwells to be grouped together into like-colored bands, and permits users to specify the coordinates and magnification of a newly-created view.

More features (a real color-chooser, scrolling, and so forth) must wait until more spare hacking time is available.

I'd be glad to distribute copies of MandelZot to interested readers; they should mail a blank Mac diskette (preferably in a diskette mailer rather than an envelope) and return postage ($.65) to me at my work address below. I'll mail back the program, documentation, and some sample data files.

Dave Platt
Coherent Thought, Inc.
3350 West Bayshore #205
Palo Alto, CA 94303
Email: "dplatt@coherent.com" or "coherent!dplatt"

AMY FIRST-CLASS

Ken Philip is the latest subscriber to ask: "If I were to send you $5, could you ship AMY by first class snail? The bulk mail issue arrived *after* the first class one you so kindly sent me, and I really think first class would be nice to have from now on."

OK OK. You domestic subscribers: $5 will get you your newsletter and slides via First Class Mail. Overseas subscribers *already* pay more to get it via Air Mail.

AUTHORS

James E. Loyless

I am a 44 year old chemical engineer / project manager whose interests go as much into art as into engineering. I was born and raised in Florida (before it was corrupted), and I am a dyed-in-the-wool Southerner (not all Southerners are ignorant).

My marriage of twenty years duration to a wonderful woman has produced happiness and three rambunctious teenagers.

I love the French and often find myself disliking Northerners from any continent (a phobia common to many native Floridians of French descent). My politics are conservative, and I think that imported cars are a ridiculous waste of money. I believe in the principle of entropy, and feel that our destinies are closely bound to the cyclical character of the universe.

My greatest accomplishment was to build a house. My favorite book is "Zen in the Art of Motorcycle Maintenance". I love to sail.

My entrée into the world of Mandelbrot started with Dewdney's famous August 1986 article in *Scientific American,* although I have always had a passion for geometry. I am into Escher and into nesting polyhedra, as well as computer programming.

I have written all my own fractal software, even after trying Bolme's FractalMagic, because I like to be in total control of what I am doing. But alas, I have not mastered machine code or assembly language; QuickBasic does everything I need. I have written a program that symmetrically nests and rotates/tips any of a series of regular and irregular polyhedra.

I have a good right brain, for a dyed-in-the-wool Southerner.

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Amygdala retains the right to maintain physical possession of submitted slides and text material, to use that material in the newsletter and the slide supplement, to reprint that material in any future retrospective volumes that Amygdala may issue, publish or have published, and to retain copyright for that use.

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SZILAGYI SLIDES

Stephen Szilagyi submitted a most remarkable and impressive zoom sequence of twenty slides. The amazing thing is that although upon close inspection each proves to be a detail of the previous one, approximately doubled in magnification, they exhibit a remarkable individual uniqueness: splendid, jewellike, ravishing.

This series is available from Amygdala for $15.00 postpaid (U.S., Canada, Mexico; $20.00 elsewhere, Air Mail).

He describes the slides as follows:

The software used was FractalMagic — EGA from Sintar Software. All slides are at a resolution of 640 x 350. The computer was an AT compatible running at 10 MHz with an Intel 80287 coprocessor. The monitor was a NEC multisync. The camera was a tripod-mounted Nikon F3 with a Tokina 80-200 F2.8 lens, using Kodak Kodachrome 25 film. The lens was set at F8 and the camera set on automatic. The exposures were generally about one to four seconds.

Due to the high learning curve while generating these plots, some of the iteration counts were a form of overkill. This did not detract from any of the slides but merely added excess time to generate some of the plots. A case in point would be #14, which took 25 hours to generate. The times for the rest of the slides ran from around 3 hours to as much as 17 hours to complete. Counting all of the time required to generate these slides and to fine tune them to my liking, I suspect that they represent over 200 hours of work. Lucky for me that the computer did the hard work while I sat around and waited, or went to work or to sleep. Again I hope that you enjoy them as much as I do.

I am 39 years old. I am a computer technician and have been one for approximately 19 years. I work for Grumman Technical Services Inc. in the Launch Control Complex shuttle firing rooms at Kennedy Space Center.

Steven A. Szilagyi
345 Mirandy Ave.
Merritt Isl., FL 32952

FRAC-L CONFERENCE ON BITNET

— Ken Philip

For those readers with access to the university telecommunications system BITNET (or to any of the other networks that can link to Bitnet), it may be of interest to know that a fractal conference was initiated on 24 August 1988. Anyone with access to Bitnet may sign on to this conference by sending the following message to LISTSERV@GITVM1:

SUB FRAC-L name

replacing 'name' with your own name. If your sign-on was successful you will receive a confirmation message with some information about commands that you can use. The moderator for the conference is Michael Burtz, and his Bitnet address is: CCASTMB@GITVM1. Sending the command GET FRAC-L NOTEBOOK will get you the messages to date, and sending REVIEW FRAC-L will give you the list of more than 200 people currently signed on. The NOTEBOOK is over 20 pages of text already, and FRAC-L promises to be a good source of information and ideas for fractal enthusiasts.

HELP!

— *Harold Tessmann*

I am teaching BASIC programming to a group of gifted elementary students at our community college and would like to give them the option of writing programs to generate fractal images. I would like to hear from readers who are willing to share program listings with us so we don't have to start from scratch. We are using Apple IIe computers but have access to Macintosh and IBM PCs. I am willing to convert from other languages or other brands of computers. I have an Apple IIGS and would like to know if anyone has written programs that use the graphics capabilities in it. I'll share our results with your readers.

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PRODUCTS

If you place an order as a result of seeing the following notice, please mention Amygdala with your order.

MANDELBROT ZOOM LENS

A Public domain program for IBM PC or compatible with color graphics.

Use the cursor keys to move the Mandelbrot fractal around on the screen. Press the PgUp key for a 2x magnification. The entire Mandelbrot display is precalculated and stored in a data compressed format. Full screen images are decoded in less than a second! An automatic movie option is available. Highest precalculated magnification is 1 inch = 0.043. At higher magnification the program switches to calculation mode, keeping track of the location of the fractal and skipping pixels deep in the Mandelbrot set to save time.

Turbo Pascal source code available to AMYGDALA readers, on request.

For a 5.25" floppy with the program and source, send $5.00 to:

Joe Gwozdz
21865 Regnart Road
Cupertino, CA 95014

FRACTAL LITERATURE IN GERMAN

A list of German literature on fractals and related subjects is available for DM 3.-- (or $1.50 U.S.) from:

Reinald Eis
Im Neuenheimer Feld 683
6900 Heidelberg
WEST GERMANY

FRACTAL EXPLORER is an easy to use, entertaining fractal creation program for the Apple II, IIc, IIe, IIGS, which includes a flexible slideshow with dazzling color effects. Online help menus and prompts guide the user along the way to create and display striking fractals derived from the Mandelbrot set and Julia sets. Newly created pictures are automatically added to the *Fractal Explorer* slideshow.

Price: $29.95, including an instruction manual, from:

ECLAT MicroProducts
P.O. Box 570-756
Miami, FL 33257-0756
Phone: 305/233-4666

THE PLOTTING SHED

Commodore 64 and 1520 Plotter/Printer software.

1315 N. 13th St.
Boise, ID 83702-3529
208/336-5241

We have the Mandelbrot Set in 1, 2, and 3 dimensions; fractals, including 3-D Land, Hopalong and many fractals from *The Beauty of Fractals;* 3-D Plot for many unusual 3 dimensional plots; plus 1520 Public Domain software and more. Write for our flyer and/or any information.

PC-SIG: MANDELBROT AND JULIA

A new fractal program has been added to the PC-Sig offerings (the shareware people) called *Mandelbrot and Julia*. This program generates and displays Mandelbrot and Julia images on IBM-PC computers with EGA or VGA graphics. Images are either 480 x 350 or 480 x 480 pixels with 16 colors. The actual dwell values are stored on disk in compressed format, so that different coloring schemes can be used.

Mandelbrot and Julia is disk #1076, and is available for $6.00 from:

PC-Sig
1030 East Duane Ave.
Sunnyvale, CA 94086

ART MATRIX; PO Box 880; Ithaca, NY 14851 USA. (607) 277-0959. "Nothing But Zooms" video, Prints, FORTRAN program listings, postcard sets, slides. Send for FREE information pack with sample postcard. Custom programming and photography by request. Make a bid.

CIRCULATION

As of October 9, 1988 Amygdala has 486 paid-up subscribers (for the new series), 206 of whom have the supplemental color slide subscription.